

A comparison of NO_x and PM₁₀ emissions and measurement trends

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Talk summary

- Estimating measurement trends
- Hourly emissions forecasts
- The problem with emissions forecasts
- What are the implications?

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Road transport measurements/emissions – new methods

1. Emissions data = Measurement data.
2. We have developed methods to estimate met. normalised trends in measurements at roadside sites in London (David Carslaw – ITS).
3. We have developed methods to create hourly road traffic and emissions and these were applied to the years 2003 to 2007.
4. This has used a comprehensive set of traffic data in London combined with new vehicle data based upon Automatic Number Plate Recognition (ANPR) cameras.
5. The use of both traffic and emissions data as hourly values has proved to be invaluable in helping interpret the air pollution measurement trends.
6. The emissions modelling results have been summarised into monthly trends between 2003 and 2007 as well as diurnal profiles by day of the week to compare with the measurement data.
7. These methods are being applied to the LAEI 2008.

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Met normalisation methods

1. Statistical methods have been developed to account for meteorological variation for assessing pollutant trends.
2. Meteorological variation can falsely mask or emphasise trends.
3. The focus has been to develop a better understanding of the traffic-related component of trends by considering roadside concentrations with background values removed.

$$[NO_x] = \bar{\mu} + \phi + T_{\theta} + t_{hour} + t_{weekday} + t_{JD} + t_{trend} + \dots$$

1. Can model non-linear relationships
2. Can account for complex interactions
3. Good treatment of missing data
4. Can be interpreted – check whether relationships are meaningful

Carslaw and Taylor (2009) Analysis of air pollution data in a mixed source location using boosted regression trees. Atmos. Env., in press.

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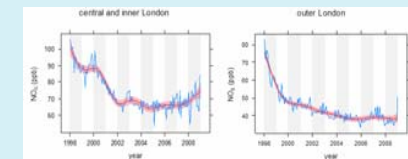
Measurement trends – sites used for the analysis of NO_x

LAGOS Site code	Site Name	Area
MY1	Marylebone Rd	Central/Inner
CD3	Camden (3)	
KC2	Kensington & Chelsea 2	
KC3	Kensington & Chelsea 3	
CD1	Camden 1	
KC4	Kensington & Chelsea 4	
IS2	Islington 2	
LB1	Lambeth 1	
HF1	Hammersmith and Fulham 1	
WIA4	Wandsworth 4	
RB3	Redbridge 3	Outer London
RI1	Richmond 1	
HS4	Hounslow 4	
HV1	Havering 1	
EN2	Enfield 2	
CR2	Croydon 2	
CR5	Croydon 5	
HG1	Haringey 1	
A30	A3 roadside	
BR7	Bromley 7	
CR4	Croydon 4	
EA2	Ealing 2	
GR5	Greenwich 5	

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Measurement trends

1. Once the meteorological signal is removed trends should represent traffic emissions
2. Can establish quantified trends rather than 'eye balling' the data.

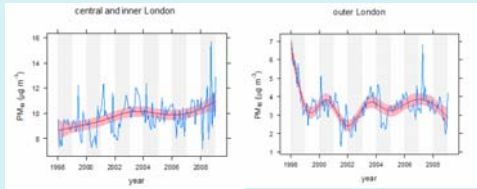


The red line shows a smooth fit to the roadside data and the uncertainty (95% confidence interval) in this fit shown by the shading.

REF: Beavers SO, Carslaw DC, Westmoreland E and Mittal H. 2009. Air pollution and emissions trends in London. Report produced for DEFRA by King's College London, Environmental Research Group and Leeds University, Institute for Transport studies

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Measurement trends (cont'd)



REF: Beever's SD, Carslaw DC, Westmoreland E and Mittal H. 2009. Air pollution and emissions trends in London. Report produced for DEFRA by King's College London, Environmental Research Group and Leeds University, Institute for Transport studies

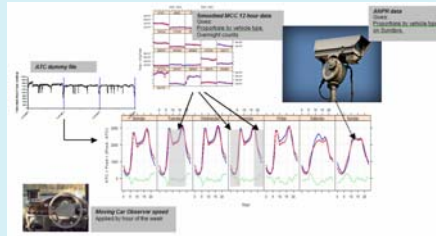
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Hourly emissions methods



Road transport flows

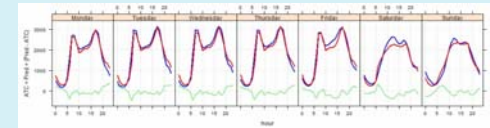


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Road transport flows -results



Comparison of predicted (red), measured (blue) and predicted-measured (light green) hourly total traffic flows. 16 site and year combinations for 2006 and 2007

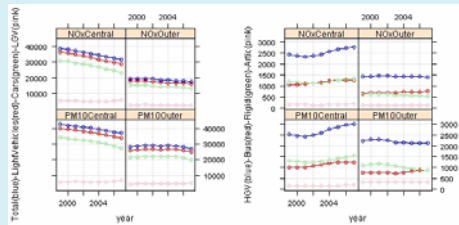
	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	All days (RMSE error)
Predicted	1859	1781	1793	1770	1793	1466	1419	
Measured	1857	1780	1779	1762	1820	1269	1481	10.7%
Mean (%) (pred-measured)/mean	0.1%	0.1%	-0.1%	-0.2%	-0.6%	-6.6%	-4.8%	
Predicted (1.2 hrs)	2379	2453	2472	2493	2471	2066	2021	
Measured (1.2 hrs)	2418	2393	2388	2397	2629	2241	2016	6.7%
Mean (%) (pred-measured)/mean	-4.1%	-1.8%	-4.1%	-3.9%	-5.8%	-7.9%	-8.8%	

REF: Beever's SD, Carslaw DC, Westmoreland E and Mittal H. 2009. Air pollution and emissions trends in London. Report produced for DEFRA by King's College London, Environmental Research Group and Leeds University, Institute for Transport studies

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Transport trends at specific sites?



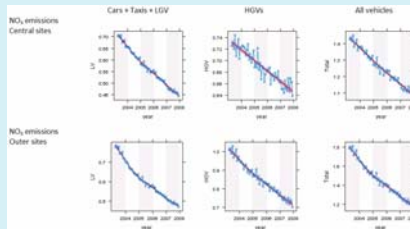
Vehicle flow trends (1999 – 2007) for all central/inner and outer sites. Total = HGV + LV, LV = Cars + LGV, HGV= Bus + Rigid + Articulated HGV.

REF: Beever's SD, Carslaw DC, Westmoreland E and Mittal H. 2009. Air pollution and emissions trends in London. Report produced for DEFRA by King's College London, Environmental Research Group and Leeds University, Institute for Transport studies

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NO_x road transport emissions trends (at AQ sites)

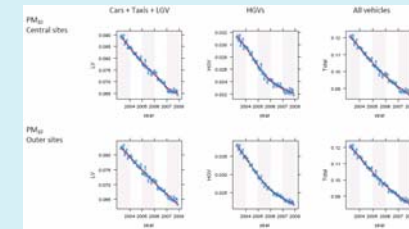


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PM₁₀ road transport emissions trends

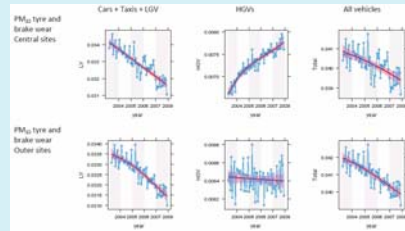


REF: Beever's SD, Carslaw DC, Westmoreland E and Mittal H. 2009. Air pollution and emissions trends in London. Report produced for DEFRA by King's College London, Environmental Research Group and Leeds University, Institute for Transport studies

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PM₁₀ road transport emissions trends – cont'd



REF: Bevers SD, Carslaw DC, Westmoreland E and Mittal H. 2009. Air pollution and emissions trends in London. Report produced for DEFRA by King's College London, Environmental Research Group and Leeds University, Institute for Transport studies



NO_x and PM₁₀ emissions trends



The percentage change in NO_x emissions between 2003 (post CCS) and 2007

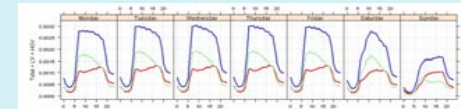
Zone	Pollutant	All vehicles	Light vehicles ¹	HGV ²	Taxis	Cars	Bus	LGV	Rigid	Artic
Central	NO _x	+20	-32	-10	-25	-41	-17	-15	-4	3
	Measured NO _x	+7.5								
Outer	NO _x	-29	-35	-25	-17	-41	-20	-21	-32	-30
	Measured NO _x	-3.5								
	Total PM ₁₀	-25	-25	-27	-43	-23	-50	-14	-17	0
	Measured PM ₁₀	-4.5								
Central	Exhaust PM ₁₀	-37	-36	-38	-47	-39	-73	-23	-25	-5
	Tyre brake PM ₁₀	-8	-7	14	-18	-10	7	15	17	30
	Total PM ₁₀	-25	-20	-38	-35	-20	-48	-18	-38	-17
	Measured PM ₁₀	-13.5								
Outer	Exhaust PM ₁₀	-37	-33	-49	-40	-35	-73	-24	-45	-22
	Tyre brake PM ₁₀	-4	-5	0	-8	7	8	2	13	9
	Total PM ₁₀	-25	-20	-38	-35	-20	-48	-18	-38	-17
	Measured PM ₁₀	-13.5								

¹Measurements from 2003-2006, ²Car + Taxi + LGV, ³Bus + rigid HGV + articulated HGV

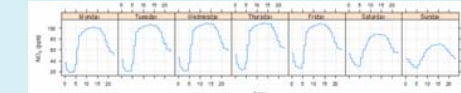
REF: Bevers SD, Carslaw DC, Westmoreland E and Mittal H. 2009. Air pollution and emissions trends in London. Report produced for DEFRA by King's College London, Environmental Research Group and Leeds University, Institute for Transport studies



Daily NO_x measurement and emissions profiles



Diurnal NO_x emissions for central and inner sites (tonnes/hr). The blue line shows the total NO_x emissions, the red line emissions from light vehicles (cars+taxi+LGVs) and the green line emissions from Heavy vehicles (HGVs + Buses).

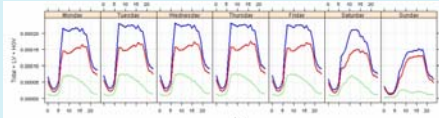


Diurnal and day of the week variation of NO_x concentration averaged across the central/inner London sites

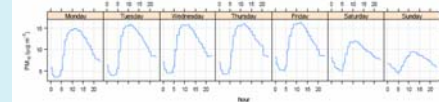
REF: Bevers SD, Carslaw DC, Westmoreland E and Mittal H. 2009. Air pollution and emissions trends in London. Report produced for DEFRA by King's College London, Environmental Research Group and Leeds University, Institute for Transport studies



Daily PM₁₀ measurement and emissions profiles



Diurnal PM₁₀ emissions for central and outer sites (tonnes/hr). The blue line shows the total PM₁₀ emissions, the red line emissions from light vehicles (cars+taxi+LGVs) and the green line emissions from Heavy vehicles (HGVs + Buses).

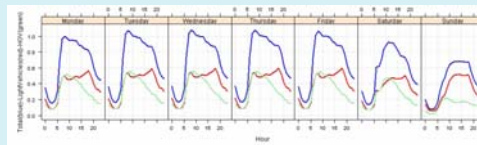


Diurnal and day of the week variation of PM₁₀ concentration averaged across the central/inner London sites

REF: Bevers SD, Carslaw DC, Westmoreland E and Mittal H. 2009. Air pollution and emissions trends in London. Report produced for DEFRA by King's College London, Environmental Research Group and Leeds University, Institute for Transport studies



Revised daily PM₁₀ emissions profiles

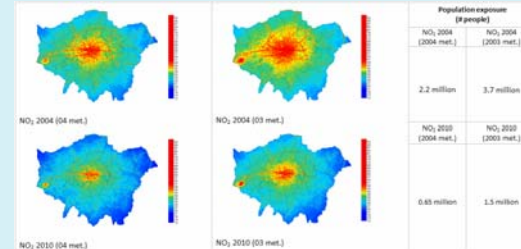


This figure uses a HGV/LGV PM emissions ratio of 11 calculated using a comparison between weekday and Sunday average meteorologically averaged PM₁₀ concentrations and traffic counts. By comparison the actual ratio in the emissions inventory is 3.9.

REF: Bevers SD, Carslaw DC, Westmoreland E and Mittal H. 2009. Air pollution and emissions trends in London. Report produced for DEFRA by King's College London, Environmental Research Group and Leeds University, Institute for Transport studies



What are the consequences of not getting it right?



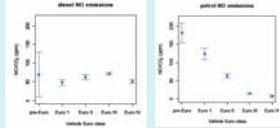
Taken from the GLA report - LAEI 2004 model forecasts.

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Emissions measurements from cars

Data supplied by James Tate (ITS)



Petrol vehicles have improved, but diesel vehicles have an almost constant emission of NO₂.

PM₁₀ mass closure in London

Trends in EC or the T&B component (trends in metals)

Elemental carbon, primary organic aerosol, iron oxide, nitrates, sulphates, secondary organic aerosol, wind blown dust and vehicle resuspension.

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What more can we do?

1. More traffic measurements please.
2. Look at London's ANPR data and specifically at what is changing within vehicle categories (vehicle weight/size/diesel vehicle(%))
3. Further data mining of the existing emissions and measurements to identify emissions inventory weaknesses by vehicle type
4. Followed by some additional vehicle tests/roadside measurements?

Otherwise...

1. How do we plan emissions reductions strategies with any confidence?

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Thanks for your attention...

Thanks also to:

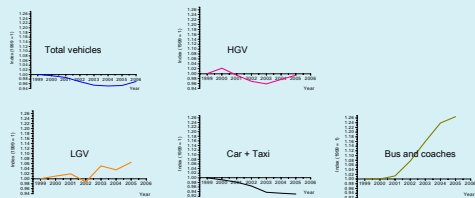
DEFRA, Transport for London (TfL)/Greater London Authority and DfT

David Carslaw, Emily Westmoreland, David Dajnak, Hrishi Mittal, Gary Fuller and David Green

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Transport trends throughout London?



London traffic changes from 1999 to 2005/6. Index (1999) = 1. Total vehicle changes taken from LEZ monitoring report (TfL, 2008).

Ref: TfL, 2008. London Low Emission Zone: impacts monitoring. Baseline report, July 2008. Report prepared for the Mayor of London by Transport for London. <http://www.tfl.gov.uk/roadusers/lez/about/2007.aspx>. Accessed 26/11/2008.

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New vs. old emissions factors?

The percentage change in emissions between 2003 and 2006		
	LAEI	DfT
CO ₂	-3.6	-3.1
ExhaustPM ₁₀	-26.7	-29.2
NO ₂	0.2	1.4
NO _x	-15.4	-18.8
TyreBrakePM ₁₀	0.4	0.4

Perhaps of more importance though is that the contribution of different vehicles to the totals has changed and as a consequence our hourly emissions modelling work, which used old LAEI version will also change.

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